The Near-Earth Object Human Space Flight Accessible Targets Study (NHATS)

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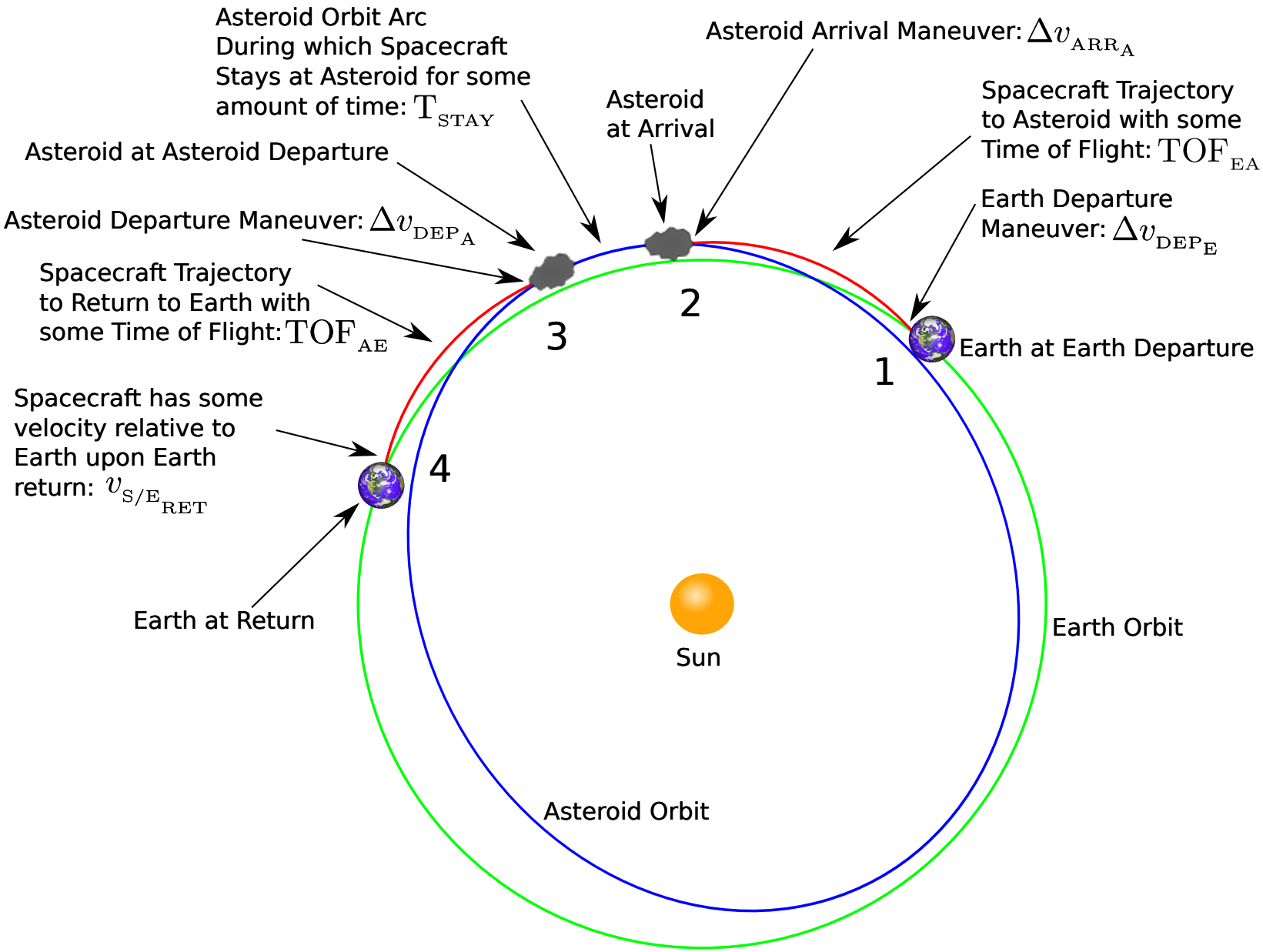
NHATS Overview

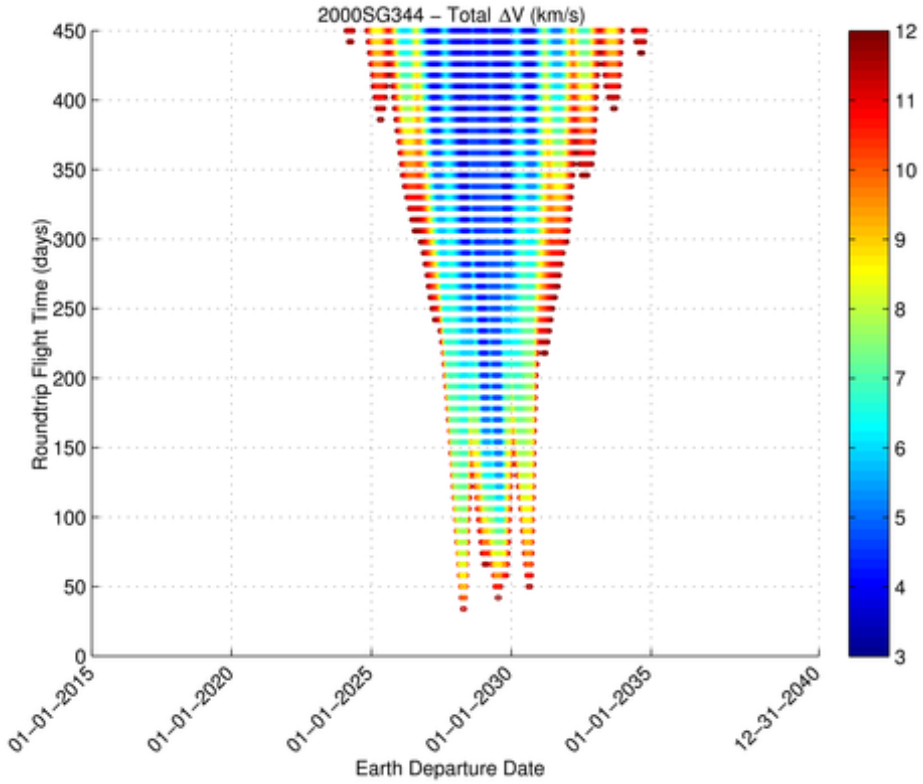
- Ongoing GSFC/JPL collaboration to automatically monitor NEA population for mission accessibility
- Began September 2010, automated March 2012
- Automated system runs daily (new/updated NEAs)
- NHATS web-site / database / mailing list
- Comprehensive mission trajectory calculations, plus next available optical & radar observing opportunities
- Rapid notification aids observers in obtaining crucial follow-up observations
- Characterization of NEAs is essential for mission planning

Profile of a Human Mission to an NEA

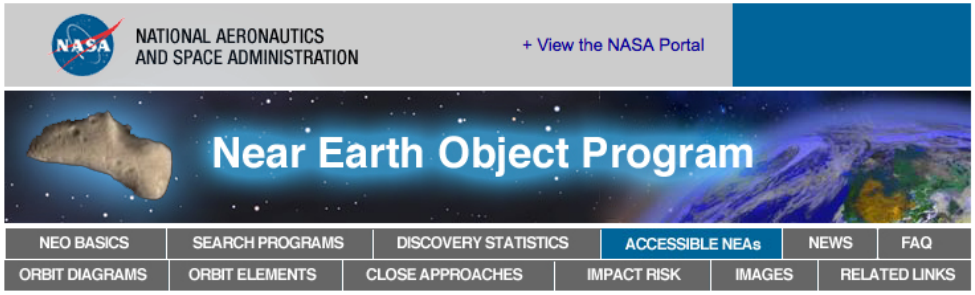


NHATS Trajectory Constraints

- Earth departure date between 2015-01-01 and 2040-12-31
- Earth departure $C_3 \leq 60$ km^2/s^2
- Total mission $\Delta v \leq 12$ km/s
  - Total Δv includes the Earth departure maneuver from a 400 km altitude circular parking orbit, the maneuver to match the NEA's velocity at arrival, the maneuver to depart the NEA and, if necessary, a maneuver to control the atmospheric re-entry speed during Earth return
- Total round trip mission duration ≤ 450 days
- Stay time at NEA ≥ 8 days
- Earth atmospheric entry speed ≤ 12 km/s at an altitude of 125 km



NHATS Web-site Table



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This list of potential mission targets should *not* be interpreted as a complete list of viable NEAs for an actual human exploration mission. As the NEA orbits are updated, the viable mission targets and their mission parameters will change. To select an actual target and mission scenario, additional constraints must be applied including astronaut health and safety considerations, human space flight architecture elements, their performances and readiness, the physical nature of the target NEA and mission schedule constraints.

[show instructions]

total dV <= 6 km/s | total dur. <= 360 days | stay >= 8 days | launch: 2015-2040
H <= 26 | OCC <= 7 | Sort by number of viable trajectories | Descending sort
Display Table
Constraints described below — reset all constraints and sorting to defaults

Column headings described below — [Selected **29** out of **1221** records]

Object Designation	Orbit ID	H (mag)	Estimated Diameter (m)	OCC	Min. delta-V [delta-V, dur.] (km/s), (d)	Min. Duration [delta-V, dur.] (km/s), (d)	Viable Trajectories	Next Optical Opportunity (yyyy-mm [Vp])	Next Arecibo Radar Opportunity (yyyy-mm [SNR])	Next Goldstone Radar Opportunity (yyyy-mm [SNR])
(2000 SG344)	15	24.7	20 - 89	2	**3.556**, 354	5.973, **114**	3302718	2028-04 [19.1]	2028-05 [3.e3]	2028-05 [59]
(2012 UV136)	20	25.5	14 - 62	1	**5.054**, 354	5.979, **282**	2112757	2014-08 [21.6]	2020-05 [570]	2020-05 [22]
(2006 BZ147)	11	25.4	14 - 65	3	**4.184**, 354	5.972, **250**	1672928	2034-12 [19.3]	2035-02 [1400]	2035-02 [38]
(2001 FR85)	11	24.8	19 - 85	2	**4.557**, 354	5.987, **162**	1618605	2038-10 [21.1]	2039-03 [99]	*none*
(2014 EK24)	23	23.2	40 - 178	2	**5.099**, 354	5.998, **330**	1067335	2014-07 [22.6]	2014-12 [14]	2016-02 [15]
(2012 MD7)	3	24.1	26 - 118	7	**5.071**, 354	5.989, **314**	867652	? *2038-02 [23.6]* ?	*none*	*none*
(2007 YF)	8	24.8	19 - 85	5	**5.426**, 346	5.965, **250**	791463	2021-12 [23.6]	*none*	*none*
(2010 JK1)	23	24.4	23 - 103	2	**5.514**, 306	5.971, **282**	775615	2033-03 [22.9]	*none*	*none*
(2001 QJ142)	21	23.7	32 - 142	0	**5.593**, 354	5.940, **338**	638369	2023-11 [19.6]	2024-04 [74]	*none*
(2012 HK31)	14	25.4	14 - 65	6	**5.746**, 322	5.924, **306**	627317	? *2022-03 [22.0]* ?	*none*	*none*
(2013 WA44)	17	23.7	32 - 142	3	**5.936**, 354	5.936, **354**	603331	2020-12 [19.9]	*none*	*none*
(2012 BB14)	9	25.0	17 - 78	3	**5.181**, 354	5.998, **306**	590985	2022-12 [21.7]	*none*	*none*
(2014 KF39)	10	25.0	17 - 78	4	**5.411**, 354	5.978, **338**	564993	2014-09 [21.6]	2031-11 [21]	*none*
(2009 HC)	31	24.7	20 - 89	4	**4.504**, 354	5.997, **298**	554669	2025-08 [22.6]	2025-10 [1300]	2025-10 [43]
(1999 CG9)	11	25.2	16 - 71	6	**5.328**, 354	5.990, **330**	541164	2033-08 [22.7]	2034-02 [60]	*none*
(2007 UY1)	31	22.9	46 - 205	2	**5.543**, 354	5.947, **338**	537652	2019-09 [23.4]	2020-10 [32]	2022-02 [18]
(2011 UX275)	3	25.8	12 - 54	6	**5.903**, 354	5.903, **354**	521511	? *2030-12 [23.2]* ?	*none*	*none*
(2001 CQ36)	31	22.5	55 - 246	0	**5.824**, 354	5.993, **338**	473271	2021-01 [20.5]	2021-02 [18]	2031-02 [150]
(2009 CV)	22	24.3	24 - 107	3	**5.709**, 322	5.934, **266**	435050	2015-11 [21.7]	2029-02 [31]	2029-03 [45]

(Available Online at: http://www.lpi.usra.edu/sbag/science/)

Accessible Near-Earth Asteroids (NEAs)

Goals of the Near-Earth Object Human Space Flight Accessible Targets Study (**NHATS**):

- Monitor the accessibility of the NEA population for exploration missions.
- Characterize the population of **accessible NEAs**.
- Rapidly notify observers so that crucial follow-up observations can be obtained.

NHATS data shown here current as of: 2014-06-07

NHATS Web-site: http://neo.jpl.nasa.gov/nhats/ **NHATS Daily Updates:** https://lists.nasa.gov/mailman/listinfo/nhats

Chart by: Brent W. Barbee (NASA/GSFC)

Selected NHATS Statistics:

Known NEAs:
11,048

NHATS NEAs:
1,211 (~11.0% of known)

Mean *H* for Known NEAs:
21.808

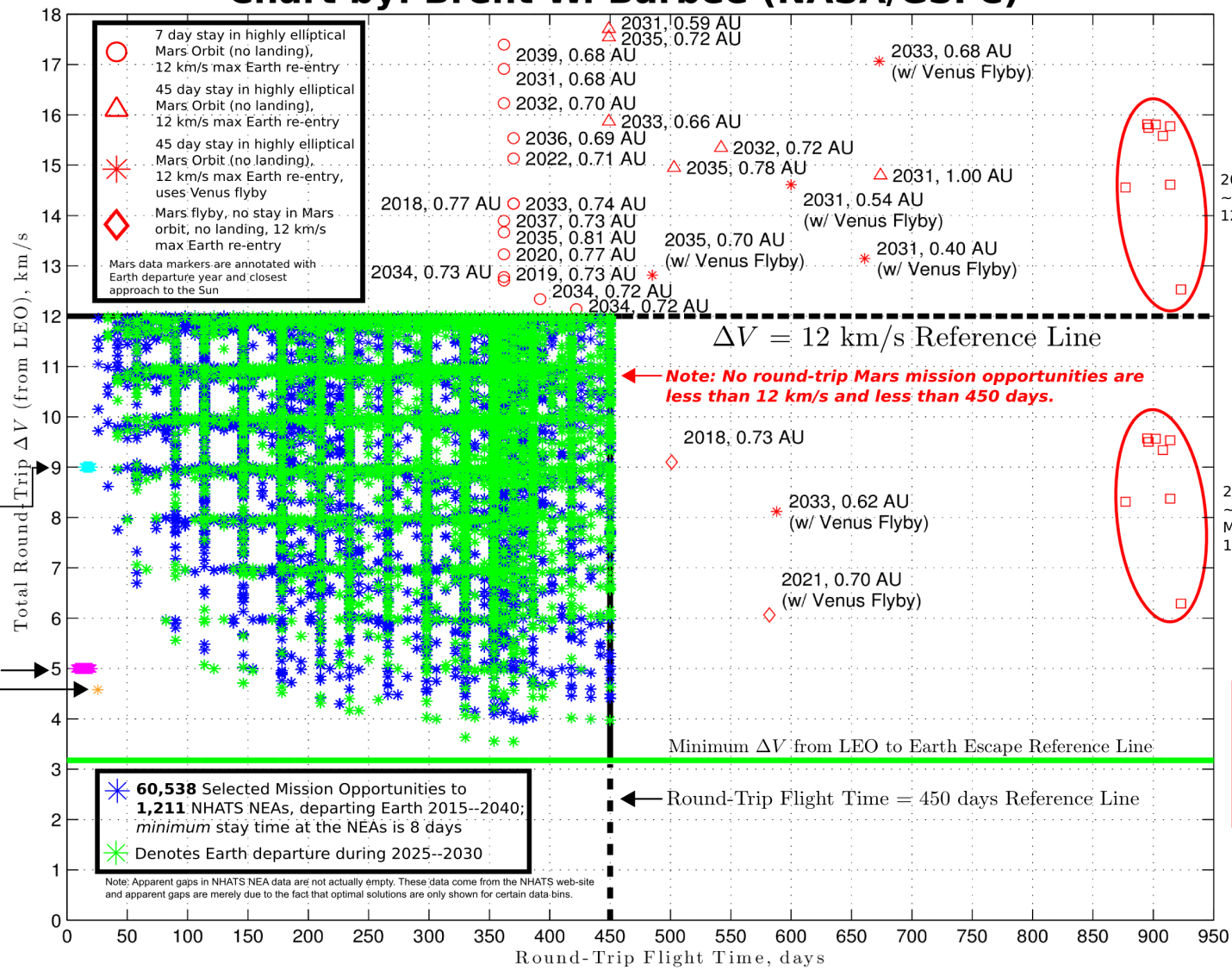
Mean *H* for NHATS NEAs:
24.806

NHATS NEAs by Orbit Type:
Atiras: 0% (0% of Atiras)
Atens: 23% (33% of Atens)
Apollos: 60% (12% of Apollos)
Amors: 17% (5% of Amors)

NHATS NEAs SMA (AU):
0.76, 1.16, 1.82
(Min, Mean, Max)

NHATS NEAs ECC:
0.01, 0.22, 0.45
(Min, Mean, Max)

NHATS NEAs INC (deg):
0.02, 5.15, 16.26
(Min, Mean, Max)



Note: Round-trip ΔV and flight time for missions to Phobos or Deimos are similar to Round-trip ΔV and flight time for Mars missions.

2031--2046 Earth Departures, ~500 day stay on Mars surface, 12 km/s max Earth re-entry

2031--2046 Earth Departures, ~500 day stay in highly elliptical Mars Orbit (no landing), 12 km/s max Earth re-entry

Round-Trip to Lunar Surface

Notes on Earth re-entry speed:
- Earth re-entry speed is approx. 11 km/s for lunar missions / ARRM
- Max Earth re-entry speed for NHATS is 12 km/s; many NHATS mission opportunites have < 12 km/s re-entry

Round-Trip to Low Lunar Orbit (no landing)

ARRM (human visitation of captured NEA in lunar DRO)

Note: Some round-trip trajectories entering Mars orbit will require additional ΔV, up to 1 km/s (or more, in some cases), for incoming/outgoing asymptote alignment. This is not reflected in the data shown here.

Mars Trajectory Data Sources:

7 day stay Mars data: Folta, D., Barbee, B. W., Englander, J., Vaughn, F., Lin, T. Y., "Optimal Round-Trip Trajectories for Short Duration Mars Missions," AAS/AIAA Paper AAS 13-808, August 2013
45 day stay Mars data: Folta, D., Barbee, B. W., Vaughn, F., "Analysis of Short Duration Round-Trip Mars Mission Opportunities During the Mid-2030s," Internal NASA/GSFC presentation, November 2011
500 day stay Mars data*: Drake, B. G., ed. "Human Exploration of Mars Design Reference Architecture 5.0 Addendum," NASA/SP-2009-566-ADD, July 2009, http://www.nasa.gov/pdf/373667main_NASA-SP-2009-566-ADD.pdf *(w/ adjustments by B. W. Barbee for 12 km/s max Earth re-entry)
Mars flyby data: Adamo, D. R. analysis of http://inspirationmars.org/Written_Testimony_DTIto_Nov2013.pdf and http://www.youtube.com/watch?v=pdu7Kk5si1k", with input from Loucks, M.